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The Technical Journal of the Soap and Edible Oil Trades

Official Organ of
The American Oil Chemists' Society

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Communications regarding manuscripts offered for publication, advertising, and subscriptions should be addressed to OIL & FAT INDUSTRIES, 220 West 42nd St., New York, N.Y.

OIL & FAT INDUSTRIES is a monthly journal published by Russell Palmer at 220 West 42nd St., New York, N.Y. Subscription: $3.00 the year, domestic; $4.00, foreign. Entered at the Post Office, N.Y., Dec. 31, 1925, as second class matter under act of March 3, 1879.

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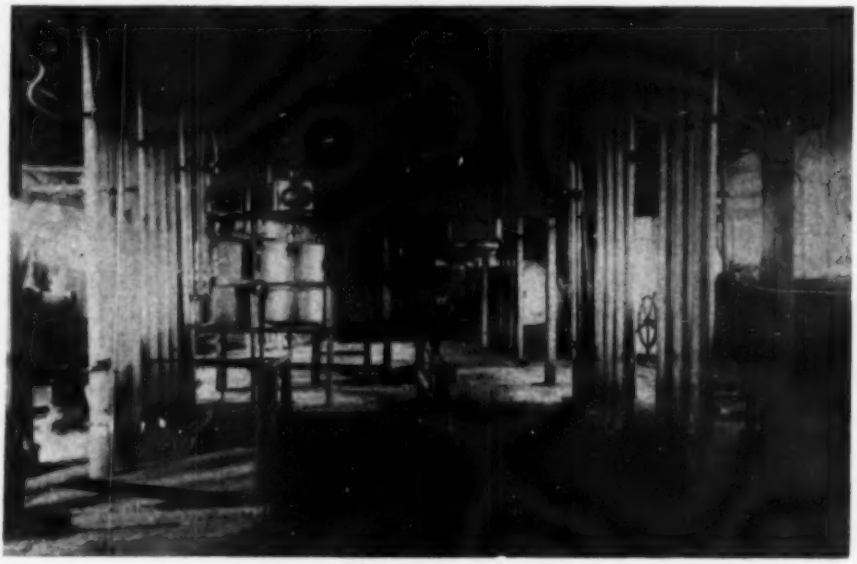
Modern Methods of Extraction by Means of Solvents

By FRANCIS M. TURNER, Chemical Engineer



Illustrating the recuperation system

UNDOUBTEDLY the greatest proportion of the output of vegetable oils in America is still being produced by means of the hydraulic press. The chief reason for this is that until very recently no better method had been developed as the various extraction methods which had been offered were not by any means entirely satisfactory. Again, there is the natural conservatism exhibited by the oil manufacturer in changing from an old and well tried system to a new method, coupled with certain advantages which the Hydraulic Press System possesses. First, the production of press cakes containing a certain percentage of oil coupled with the fact that the press cakes may be shipped without any special bagging or packing. Local conditions are another factor entering into consideration as in places where water is scarce it is not so important in the case of the hydraulic press as in the Solvent Extraction System.

But, on the other hand, the hydraulic press method has many serious disadvantages when compared with the modern solvent extraction system. For instance, one must take into account the much higher cost of equipment coupled with the greater weight of pumps, presses,

accumulators, "cookers"; the constant and expensive repairs, the continual cost of press cloths and most important the much greater amount of labor and higher wages.

Then there is the deficient yield of Oil by the hydraulic press method, when compared with the modern extraction system. This of course varies with the type of hydraulic press, the skill and care exercised in their operation, and with the technical knowledge of "cooking" on the part of the employees. The oil content in the press cake varies from 5 per cent to 15 per cent, occasionally more (the average being 8 per cent to 10 per cent).

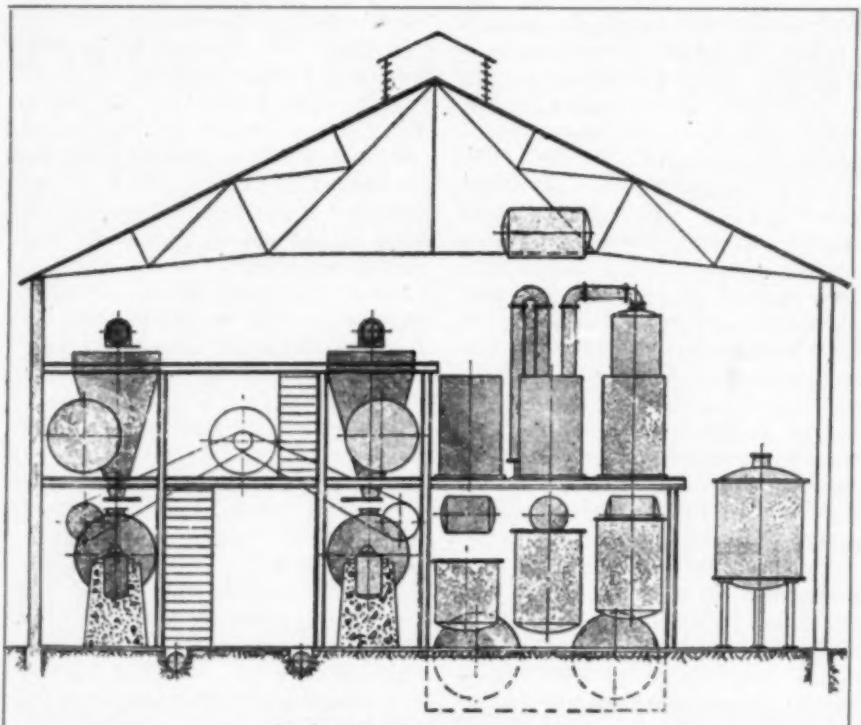
It is admitted that a small percentage of oil for feeding purposes is desirable in the press cakes or meal; but excessive amounts pass through the animal undigested, as has been proven, and it signifies a great economic loss. Feeding authorities in Europe state that not more than 1 per cent fat in feeds can be utilized; more than that is detrimental to the assimilation of that essential in foods, protein.

The Inferior Quality of the Oil is a point of great importance. On account of the direct steam used in the "cookers," mucilaginous substances are liberated which under pressure enter the oil. These impurities must be removed either by settling or filtration or other means of clarification, which adds expense.

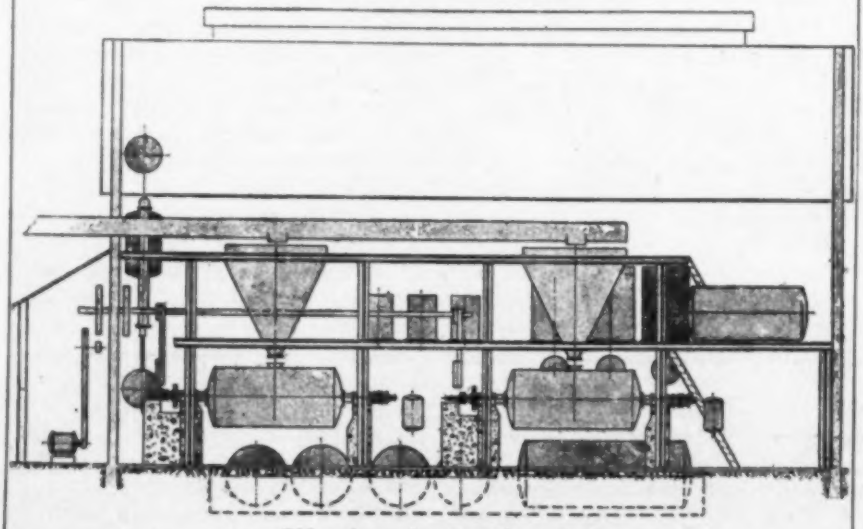
Again in the cooking process previous to hydraulic pressing, steam is introduced into the oil seeds in the cookers; heat plus moisture induces hydrolysis deteriorating the quality of the oil: its influence on color and increase of the free fatty acid is well known.

Since 1843 when Fisher of Birmingham (England) introduced extraction, many endeavors have been made to use the extraction method, as it was realized to be more simple and economical in operation. It is interesting to follow the early types of extraction apparatus—English, French, German and American. All were more or less unsuccessful in reaching the ideals of the process, which can be said to secure the complete removal of the oil or as much of it as it is desired to recover in one stage and should leave the residue of the seed in a dry state. Many extraction plants fall short of this ideal, inasmuch as the meal after extraction has to be separately dried. The methods in the past were also more or less unsuccessful, owing to the fact that it was almost impossible to obtain oils and meals free from taste and odor of the solvent employed and of as good color as by hydraulic pressing and last the greatest obstacle to its use—the constant danger of explosion. These serious disadvantages were due in the most part to faulty design and mechanical construction. For instance, the use of vertical or horizontal stationary extractors, in which direct steam was blown through the extracted mass in order to eliminate the last traces of the solvent, was found to be not only objectionable in regard to quality of meal but a very dangerous practice as well (reference is made to this later).

In the old fashion extraction system, in which direct steam was blown through the extracted meal, not only was the color of the meal influenced unfavorably, but the proteins (the essential food principle) were coagulated, losing much of their digestibility because they were no longer water soluble and consequently were not so readily



End view of extraction plant



Side view of extraction plant

assimilated when fed to the animal.

Again with oil seeds having a large mucilaginous content; such as Linseed, for example, when steam was blown through the extracted meal, caking took place, forming balls of the extracted meal. These, when dried, were hard on outside and soaked with solvent inside. When these balls were ground, explosions often took place. In fact, the great explosion at the plant of J. Bibby & Co., Liverpool, was traced to this cause. Also, the steam blown through condenses and it will be found that often there is a moisture content in the meal running as high as 35 per cent and therefore a severe after-drying must be resorted to.

The necessity for increasing the production of oils and fats during the Great War stimulated invention and in Europe, particularly Germany, great advances were made. Finally a System of solvent extraction was devised that has entirely overcome the objections that existed formerly and that carries out the process to perfection.*

This introduces a new era in the history of extraction, the ideals are fully met and by the introduction of special apparatus the fire hazard and danger of explosion that existed heretofore is entirely eliminated.

The Extraction Plant consists of:

1. The Extractors proper with built-in Heatable Filter Tubes
2. The Distillation System
3. The Recuperation System

The Extractors are horizontal, jacketed, rotary with inserted heatable filters and operate in vacuo. They are constructed in two sizes, viz. 1.8 meters (6 ft.) and 2 meters (6 ft. 6 in) in diameter and 4 meters long (13 ft.), capacity varying from 5 to 7.5 long tons in 24 hours.

Loss of Solvent during operation. The loss of solvent is guaranteed not to exceed 1 per cent based on the weight of the material to be extracted. However, practical experience has shown the loss to be very considerably less.

Consumption of Steam. This amounts in the case of oil bearing seeds to about one pound of steam to one pound of the weight of the raw material although if care be exercised considerable savings are still possible.

Consumption of Power. The rotation of the extractors require very little power. For instance, a plant having a capacity of 5 to 6 tons per day 20-30 Kwh. is used, 10-12 tons 40-60 kwh., 20-25 tons 100-120 kwh. It is evident that the cost of power is negligible.

Consumption of Water. The consumption of water is about 12 times the consumption of steam, therefore, a 5 to 6 ton plant will require about 60 cubic meters (14,500 gals.)

Labor. The amount of labor required is two to three men per shift on plants up to 20 to 25 tons per day providing conveying assistance is supplied to and from the plant.

Yield. With the extraction process it is possible to obtain the entire oil content of the raw material, but, commercially leaving 1 per cent or fractions thereof in the residual meal are sufficient. On the other hand should a higher oil content or absolute removal be desired, it is entirely within the will of the technical manager.

Quality of Extracted Oil and Meal. The extraction method removes only the fats and oils. Proteins and mucilaginous materials are not sol-

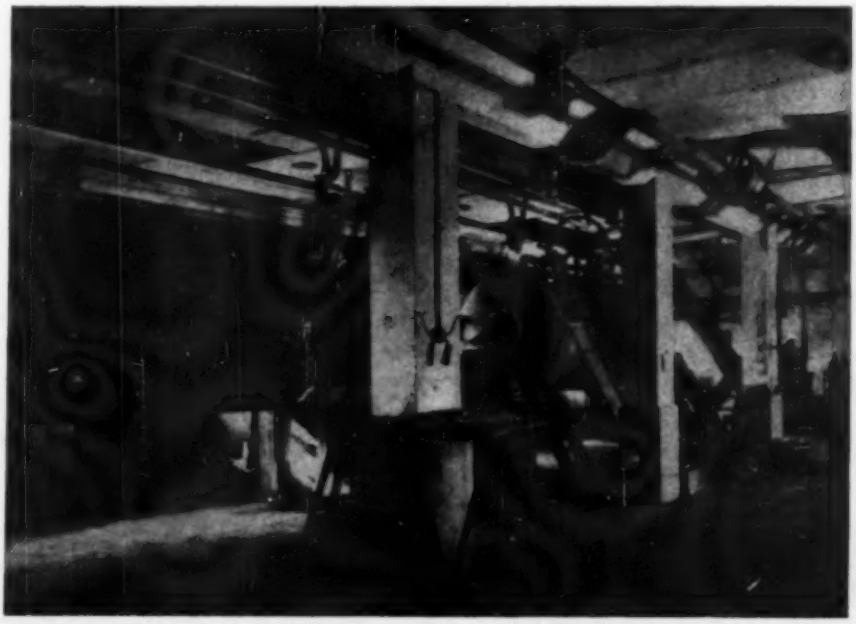
* Reference is made to the Rotary Vacuum Extractor—Karl Friedrich Wilhelm patents.

uble in the solvent. The quality of the oil obtained is exactly the same as that contained in the raw material—it is not deteriorated as is the case in the hydraulic pressing process. The oil is free from "foots." The oil extracted meals are generally white and flaky and in any event much lighter in color than hydraulic press cakes. The proteins contained are water soluble and therefore fully digestible.

Manner of Operation

The previously cleaned oil bearing seeds are placed on suitable crushing machines in order to be rolled out in the form of flakes. This is done in the manner that the roughly ground seeds are fed to a pair of smooth rollers. The leaflike material goes into a hopper arranged above the extractor. The latter measures the quantity required for the filling of the extraction apparatus. The extractor is jacketed horizontal, cylindrical and rotatable. The filling is effected by means of a manhole the cover of which can be placed on and removed within a few minutes. After the closing of manhole the necessary quantity of solvent is introduced into the apparatus and the extractor is rotated, while simultaneously steam is introduced into the jacket. The extractor is rotated but a few times so that every particle of the material comes in contact with the solvent, in this way being thoroughly saturated. Then, the apparatus remains at rest for a few minutes in order to give the material an opportunity to settle; i.e. to separate from the miscella or mixture.

The Miscella (i.e., mixture of fat



Showing the arrangement of the extractors

and solvent) is then drawn off by vacuum through filters, built radially in the extractor, into a storage tank for re-use in a second extractor if the fat content of the material to be extracted is small or if it be large, into a still where the solvent is distilled off under vacuum. In a similar manner the material in the extractor is subjected to a second, third and perhaps fourth wash ing until the fat content of the material to be extracted is found to contain not over 1 per cent of fat, the mixtures in each case being stored for re-use in other extractors before going to the still. After sufficient washings have been made the extractor is again rotated. Steam is applied in the jacket and the solvent remaining in the now extracted meal is recovered by means of vacuum. The residual meal can now be discharged bone-dry and ready for disposition. If it be desired, steam may be fed into the extractor to moisten the meal slightly so as to bring it up to the humidity of the atmosphere. In the stills the solvent is driven off under vacuum at a very low temperature, recovered by condensation. Both oil and meal are devoid of odor or taint of solvent.

While the majority of extraction plants are used in the vegetable oil industry, many are employed for the purpose of obtaining oils, fats and greases from all kinds of fat-bearing materials such as bones, slaughter-house waste, butcher's trimmings or shop fat, "cracklings," fish and fish cuttings, hydraulic press cake and parings, Fuller's earth, bleaching earth, spent catalysts, and fatty substances of mineral origin, such as Montan wax from lignite.

Another view of the extractors showing the rotating mechanism

Castor Oil as a Lubricant

By C. P. HARRIS, Ph. D.

AMONG oils, the product of the castor bean, *Ricinus Communis*, possesses several unique properties. It has a very high specific gravity and a viscosity of a magnitude far greater than that of any other known untreated oil. These very valuable properties have pointed to its use as a lubricant and it has met with success, especially in bearings carrying heavy loads. However, its tendency to become rancid when exposed to heat and air have militated against its use. But in cases where the lubricated surfaces are not exposed to air, its use should not only be unobjectionable but highly advantageous. Until a few years ago the only tests applied to an oil so far as lubricating properties are concerned were the viscosity and power consumption or friction test. All the other tests made referred to the purity and stability of the oil. It has recently been recognized, however, that two oils of the same viscosity may have quite different lubricating values due to another factor, which, for lack of a better name is called "oiliness." Castor oil is pre-eminent in the possession of oiliness and its use as a lubricant will doubtless be stimulated by consideration of this new factor. Oiliness has been defined as "the capacity of the oil to form on the bearing surfaces an absorbed film, which will resist rupture at low speeds and high loads and thus prevent *metal-to-metal contact and abrasion*."[1] It seems quite clearly to be a function of the chemical constitution and largely independent of the viscosity. The viscosity, of course, is of great importance in this connection and viscosity and oiliness are the chief factors influencing lubrication.

Both of these properties depend upon the chemical nature and constitution of the oil. Mineral oils are hydrocarbons which are saturated and inert under ordinary conditions. Some mineral oils have measureable iodine numbers and they vary among themselves in this respect, but the magnitude of this property in mineral oils commonly used as lubricants is negligible compared with measurements of unsaturation in animal and vegetable oils. The former consist chiefly of paraffin hydrocarbons and the presence of other elements such as sulphur or nitrogen is accidental. Except for the very high flash point cylinder and engine oils the viscosities are lower than those of most vegetable and animal oils. In fact, it appears that in any given chemical series, such as the paraffin hydrocarbons, the viscosity is a function of and varies directly with the increase of the molecular weight. It has been observed that unsaturation of the molecule increases the viscosity and for purposes of comparison a paraffin base lubricating oil is a completely saturated substance. This partially accounts for the fact that of mineral and vegetable oils of similar molecular

[1]Parsons and Taylor. *Journal of the Institute of Engineering Chemists*, Vol. 18, 1926, p. 493.

[2]A. E. Dunstan and F. B. Thole. *Journal of the Institute of Petroleum Technology*, 1918, page 191.

weight, the vegetable oils usually have the greater viscosity. Another structural factor affecting viscosity is the symmetry of the molecule. Molecular symmetry tends to decrease the viscosity.[2] This is an interesting idea, as the viscosity is thought to be due to the "internal rubbing" of the molecules against each other. Apparently molecular symmetry makes for a small amount of internal friction of the molecules. And here is another reason assignable to the difference of observed viscosities in animal and mineral oils. Pure paraffin hydrocarbons are remarkably symmetrical, whereas vegetable and animal oils, besides containing various different radicals in the molecule often possess asymmetric carbon atoms, that is, carbon atoms, each of whose valence is satisfied by a different radical.

Vegetable and animal oils are closely related chemically and consist of triglycerides of fatty acids. They differ from one another according to the properties of their acids. Sperm oil is a mixture of waxes, that is, *mono*molecular compounds of fatty acids with an alcohol of high molecular weight. Castor oil stands out in this group with a viscosity approximately seven times as great as that of other members.

Probably all chemical compounds possess the property of residual affinity in some degree. By this term is meant the activity and capacity for further combination with other substances. Atoms are ordinarily in a highly active condition and combine readily to form molecules. Molecules, in turn while much less active combine with other molecules, indicating that a mutual force of attraction previously existed. In some cases these molecular combinations are so loosely held together, as, for example, in the formation of certain hydrates, that the existence of the compound must be detected by delicate changes in certain physical properties, such as the formation of maxima in freezing point curves. In other words, there are all degrees of activity of chemical combination varying from a comparatively strong and stable compound formation to an extremely loosely held and easily disintegrated substance.

Adsorption is, doubtless, not to be considered a form of chemical combination, but in many cases it exhibits phenomena similar to a very loosely combined compound. Adsorption of active gases by finely divided charcoal, occurs quantitatively under proper conditions and can be made to reverse like a chemical combination. The fact is, that at the border line, it is difficult to distinguish between an adsorbed surface phenomenon and a chemical reaction. At any rate, the more chemically active substances are more readily and avidly adsorbed. This idea is applicable to the property of oiliness of lubricants.

It has already been stated that vegetable oils in general, and castor oil in particular, have not only higher viscosities, but also greater degrees of oiliness for equal molecular weight. The difference in residual chemical activity seems to explain the observed differences in these properties. In each of the three acid radicals combined with glycerin in a triglyceride there are two atoms of oxygen which possess additional combining ca-

pacity. One of these atoms is assumed to be connected to the carbon atom of the carboxyl group by a double linkage, the other is represented as having one valence satisfied by the carbon of the carboxyl group and the other by one carbon of the glyceryl radical. But oxygen can and does exist in tetra valent form[3]. So that in a carboxyl radical the oxygen atoms have residual chemical affinity. This accounts for part of the activity of these oils.

If the carboxyl group is not combined in the form of ester the reactive capacity is increased by the presence of a labile hydrogen atom; and it is noticed experimentally that the presence of uncombined fatty acid in mineral oils or in vegetable oils has decreased the static coefficient of friction, which is considered to be a measure of the property of oiliness. Unsaturated linkages between the carbon atoms composing the acid radical of oils naturally increases their reactive power. The number of unsaturations has long been recognized as an important property cf oils but more from the viewpoint of oils suitable for paint manufacture. The iodine number is a meaure of this unsaturation and it is found that the property of oiliness varies directly with the increase of unsaturation of carbon linkages. Small variations of iodine absorption cannot be detected by measurement of oiliness, however, and small differences in this constant in mineral oils are not noticeable.

The presence of the hydroxyl radical introduces another unsaturated group.[4] The oxygen of this group possesses the property of becoming tetravalent, a procedure which probably is antecedent to many of its customary reactions. The hydrogen of the group can be replaced by acid radical to form esters, as in the alcohols. Castor oil is the only common hydroxylated oil and some of its characteristic properties are due to the presence of this group. The property of forming "sulphonated" castor oil is due to the reaction of the hydroxyl group with sulphuric acid, resulting in what amounts to an ester of sulphuric acid. The carboxyl, hydroxyl and unsaturated group and the asymmetric carbon atom are all present in the acid radical of castor oil, which fatty acid is known as ricinoelic from its derivation. The formula for this acid is:

$$CH_3\ (CH_2)_5\ C\ HOH = CH_2 = CH = CH\ (CH_2)_7 = COOH.$$

The underlined carbon is asymmetric. The combination in one molecule of both carboxyl and hydroxyl groups seems to increase lubricating power to a marked degree[5]. Esters of lactic acid, CH_3 CHOH=COOR although of a very low molecular weight demonstrate this property.

There are three types of friction. First, there is the friction between perfectly dry clean surfaces, either flat or balls and rollers rotating against a bearing; second, there is the friction of partial lubrication where the surfaces are covered with a very thin film of grease or oil, not enough to prevent metal to metal contact, and third, there is

[3]Kendall, *Journal Amer. Chem. Society*, **36**, 1722 and **37**, 100.

[4]Faulk and Nelson. *Journal Amer. Chem. Society*, 37, 1732 (1915). Standinger, Ber. **46**, 3520. H. Goldschmidt, Zeitschrift Electrochemie. **14**, 581.

[5]W. B. Hardy. Fourth Report on Colloid Chemistry and Its General and Industrial Applications. British Association, 1922, p. 196.

the friction of completely lubricated surfaces, where there is always a film of oil separating the metals and where the friction is due simply to the vicosity of the lubricant.

Partial lubrication is likely to occur in bearings moving at low speed, or at high pressure or both. A high speed of rotation has a tendency to "drag" the lubricant around with the bearing, low speed the reverse. High bearing pressure, naturally, exerts a tendency to break the fluid film and cause partial lubrication and metallic contact. Any bearing can be operated with a given lubricant so that either partial or complete lubrication will take place. The point at which the change occurs is called the critical point and is indicated by a sharp rise in the frictional coefficient.

In the region of complete lubrication the viscosity of the oil determines its efficiency as a lubricant, assuming its safety and stability factors to be satisfactory. But in partial lubrication the oiliness is the dominant factor. An exaggerated case of partial lubrication is illustrated by the lubrication of cutting tools where a heavy cut is taken. Here, fatty oils only are found satisfactory. A mineral oil compounded with a fatty oil and which gives similar results in static friction tests does not work as well for this purpose, probably because the high temperature at the cutting point alters the lubricating property of the compounded oil to a greater extent than the straight fatty one.

As castor oil, possesses the most desirable lubricating qualities of the fatty oil group, compounded mineral and castor oils might be expected to have value. This has been found to be the case. However, the solubility curve of castor and mineral oil is a peculiar one. Castor oil in small percentages is insoluble in mineral oil and as little as 0.5 per cent causes turbidity at room temperature. Equal quantities of castor and mineral oil, however, give a homogeneous solution, and the characteristic insolubility of castor oil is lost even in small quantities if a small amount of soluble oil, or a mutually soluble oil is added. Patented methods exist which have for their purpose the rendering of castor soluble in mineral oil. These depend mainly upon heating the castor oil, either alone or with reagents.

Castor oil is distinguished chemically by its high acetyl number, about 150, a measure of its hydroxyl groups, its solubility in alcohol, in which one part dissolves in four at ordinary temperature and its high maumené test. Physically it is distinguished by its high gravity, high viscosity and low solidifying point. Within the last few years, however, new and important lubricating tests have been devised. These consist of (1) the surface tension, (2) the interfacial tension, and (3) the static coefficient of friction, the measurement of oiliness. The surface tension and interfacial tension between oil and water are measured by means of a Traube stalagmometer, by dropping water into oil through a capillary tube. The value of these two tests is somewhat in doubt as investigators disagree as to the relation of interfacial tension to coefficient of friction. It seems, at least possible, that low interfacial

(*Continued on page 37*)

[4]Report of Lubricants and Lubrication Committee, Department of Scientific and Industrial Research. London, 1920.

Comparison of Emulsifying and Deflocculating Powers of Soaps Upon Oil and Carbon Black

By ROBERT M. CHAPIN

Bureau of Animal Industry, U. S. Department of Agriculture

WHEN presenting their carbon black test for the "detergent action" of soaps McBain, Harborne and King[1] surmised that the effect of a soap on carbon black might be to a certain extent specific and not wholly parallel with its effect on oily matter. To settle this question the writer has undertaken comparative experiments involving the filtration of oil emulsions and of carbon black suspended in soap solutions.

With exceptions to be noted, the technic was similar to that previously used[2] in experiments upon carbon black. Quantities of 20 cc. of various dilutions of a stock soap solution in test tubes were heated, after complete solution and mixing, for 0.5 hour at a temperature at least 10° C. higher than the projected temperature of the test. The tubes were transferred to the special water bath, described in the previous paper, in which they were agitated 20 minutes and left at rest 10 minutes. The charges of oil or of carbon black were then added and the tubes were rotated at 20 to 22 r.p.m. for 40 minutes, after which the contents were filtered through standardized filter papers contained in funnels immersed in the same water bath. The temperature of the bath was held constant from the first immersion of the tubes until all the filtrates had been collected. The quantity of oil or of carbon black found in a fixed first portion of each filtrate was taken as a criterion of the emulsifying or deflocculating power of the corresponding soap solution.

[1] Jour. Soc. Chem. Ind., **42**, 373 T (1923).
[2] Ind. Eng. Chem. **18**, 1313 (1926).
[3] Kolloid. Z. 36, Ergänzungsband. Zsigmondy Fest-schrift, p. 196. (1925).

Emulsification of Oil

The oil was taken from a single container of laxative mineral oil which had been found free from acid and to suffer no change in weight at 105° C. The charge employed was the quantity delivered by the same wide-tipped 1 cc. pipet, with its stem wiped dry, in an outflow time of 1 minute. The filter papers were selected to pass 10 cc. water at room temperature within 18 to 23 seconds after 20 cc. had been poured on. The volume of each filtrate was 10 cc. This was rinsed with hot water into a separatory funnel, acidified with hydrochloric acid and cooled. The total oil and fatty acid was extracted by ether, washed free from mineral acid and weighed after drying to constant weight at 105° C. Neutral alcohol and phenolphthalein were next added to the residue and the fatty acid was determined by titration. Thus the weight of the oil was found by difference, a procedure earlier employed by Gurwitsch[3]. Both palmitates and oleates carried so little oil through the filter paper that the work had to be confined to stearates.

Experiment 1. The results af-

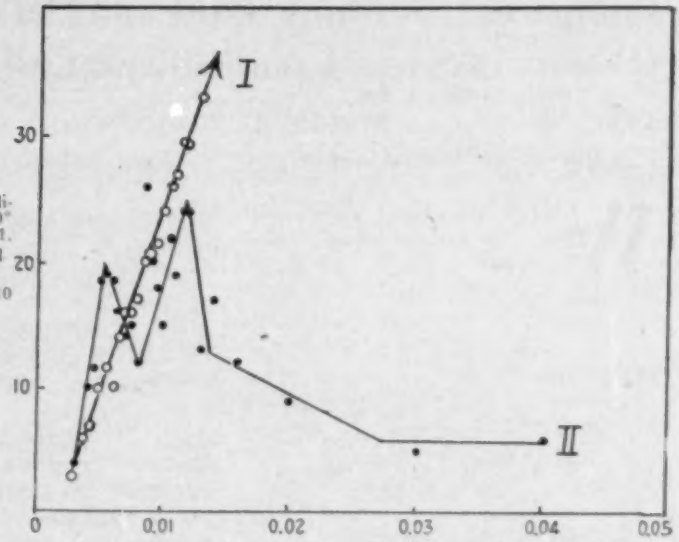


Fig. 1
Oil and Neutral Sodium Stearate at 70° C. in Experiment 1.
Horizontal — Normality of soap.
Vertical—Mg. in 10 cc. filtrate.
Curve I—Stearic acid.
Curve II—Oil.

forded by neutral sodium stearate at 70° C. are given in Figure 1, and those at 60° C. and at 50° C. in Figure 2. At 50° C. no filtrate was found to contain more than 2 milligrams stearic acid.

Experiment 2. Alkaline solutions of sodium stearate were tested at 70° C. by the procedure of Experiment 1. Results are given in Figure 3. The curves for fatty acid in presence of 0.002 and 0.005 N excess sodium hydroxide practically coincided with Curve I, and this, it will be noted, is practically superposable upon Curve I of Figure 1.

Experiment 3. In this experiment the soap solutions contained 0.005 N stearic acid in excess. The tubes were first charged with 5 cc. of a solution of 1.1376 g. stearic acid in 200 cc. alcohol, then the alcohol was expelled by heat, first

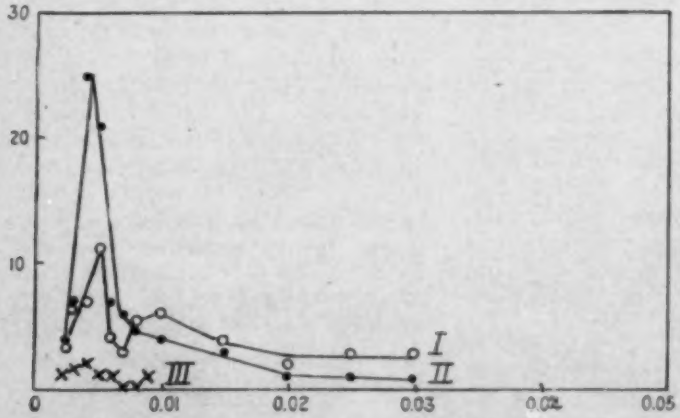


Fig. 2
Oil and Neutral Sodium Stearate at 60° and 50° C. in Experiment 1.
Horizontal — Normality of soap.
Vertical—Mg. in 10 cc. filtrate.
Curve I—Stearic acid at 60° C.
Curve II—Oil at 60° C.
Curve III—Oil at 50° C.

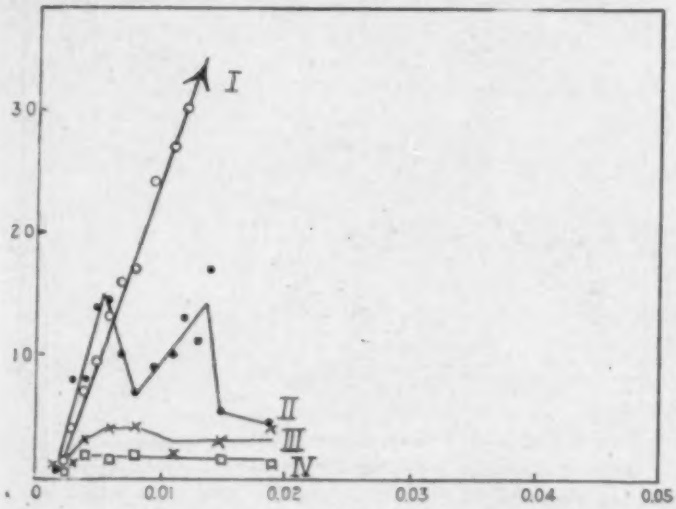


Fig. 3

Oil and Aklaline Sodium Stearate in Experiment 2.

Horizontal — Normality of soap.

Vertical—Mg. in 10 cc. filtrate.

Curve I—Stearic acid in presence of 0.001 N excess NaOH.

Curve II — Oil in presence of 0.001 N excess NaOH.

Curve III—Oil in presence of 0.002 N excess NaOH.

Curve IV—Oil in presence of 0.005 N excess NaOH.

in a water bath and finally in an oven. After being further charged with neutral soap solution the tubes were carried through as in Experiments 1 and 2 except that during the preliminary heat treatment they were vigorously shaken twice to distribute the excess stearic acid. The results are given in Figure 4, in which the scale of the ordinates is only one-fourth the scale in Figures 1, 2, and 3.

In the cited work on carbon black the writer demonstrated that a soap solution may show two peaks of deflocculating power. The anterior peak, at the lower concentration, was attributed to the action of soap anions, the posterior to the action of simple soap molecules. It now appears that soap solutions may show two peaks of emulsifying power also.

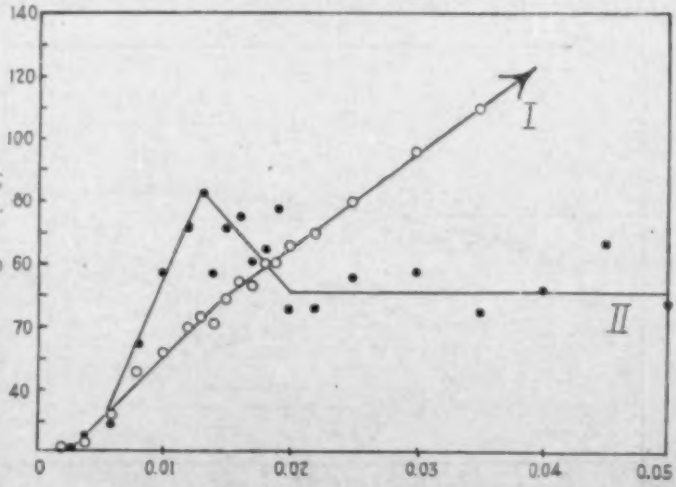


Fig. 4

Oil and Acid Sodium Stearate at 70° C. in Experiment 3.

Horizontal — Normality of soap.

Vertical—Mg. in 10 cc. filtrate.

Curve I—Stearic acid.

Curve II—Oil.

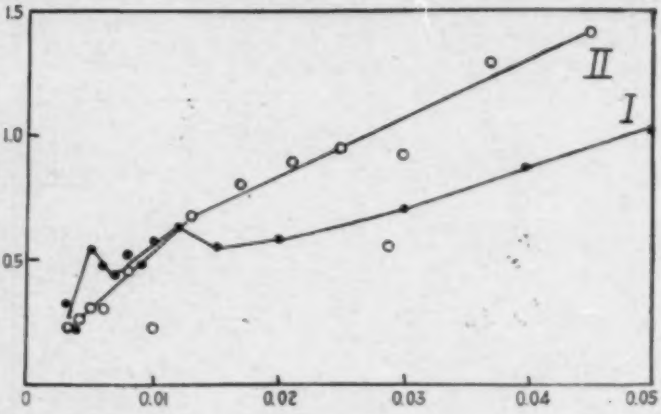


Fig. 5
Colored Oil and Sodium Stearate at 70° C. in Experiment 4.
Horizontal — Normality of soap.
Vertical — Mg. color in 10 cc. filtrate.
Curve I — Neutral stearate.
Curve II—Stearate plus .01N excess NaOH.

The Distribution of a Color

Experiment 4. The foregoing method of arriving at the weight of oil carried through each filter is so tedious that an attempt was made to employ an oil-soluble color as an indicator for the concentrations of oil in the filtrates. A solution of 1 gram of dimethylamidoazobenzene ("butter yellow") in 100 cc. of the mineral oil was used instead of plain oil. After the 10 cc. of each filtrate had been collected and rinsed with hot water into a separatory funnel, 5 cc. concentrated hydrochloric acid was added and after cooling, 25 cc. petroleum ether or ethyl ether. Then the color was completely extracted by successive washings with diluted (1:3) hydrochloric acid, the extracts being received in 100 cc. graduated flasks. The contents of the flasks were made to the mark and filtered through plugs of cotton, with rejection of the first runnings. The quantity of color in each filtrate was determined colorimetrically in either a colorimeter or Nessler tubes against a standard obtained by pipetting 1 cc. of the colored oil directly into a

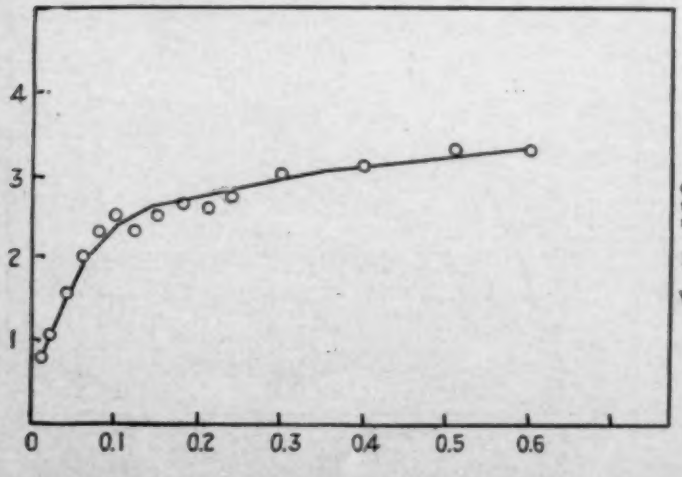


Fig. 6.
Colored Oil and Neutral Potassium Palmitate at 40° C. in Experiment 4.
Horizontal — Normality of soap.
Vertical — Mg. color in 10 cc. filtrate.

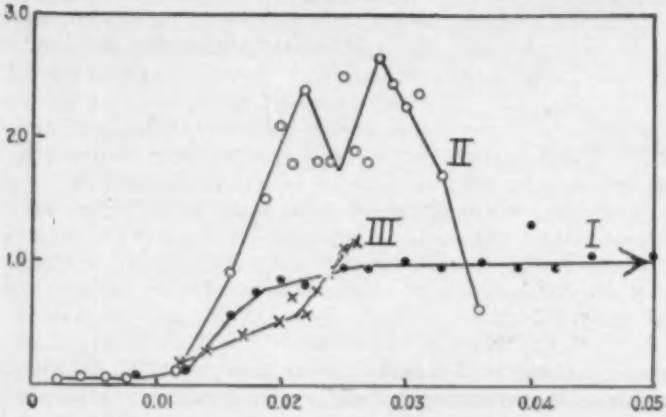


Fig. 7.
Naked Carbon Black and Neutral Sodium Stearate at 70°, 60° and 50° C. in Experiment 5.
Horizontal—Normality of soap.
Vertical—"Color ratio" of filtrate.
Curve I—at 70° C.
Curve II—at 60° C.
Curve III—at 50° C.

separatory funnel, extracting with acid and making to a volume of 200 cc. with the diluted hydrochloric acid. The results obtained on neutral and alkaline sodium stearate at 70° C. are given in Figure 5 and the results on neutral potassium palmitate at 40° C. in Figure 6.

It is evident that with increasing concentration of soap the quantity of color appearing in the filtrate becomes increasingly out of proportion to the oil found to be carried through in Experiments 1 and 3. Apparently colloidal soap in the aqueous phase extracts color from the oil phase. Two important consequences follow. First, a method of this sort offers little promise for the laboratory comparison of the emulsifying powers of different

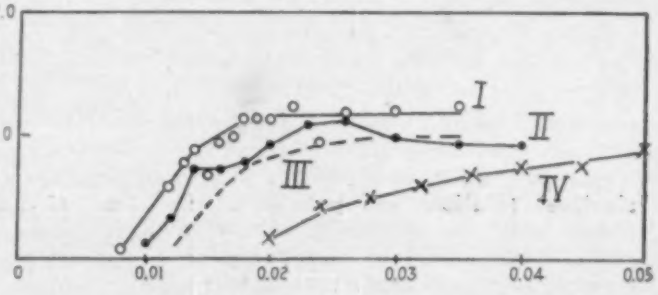


Fig. 8.
Naked Carbon Black and Acid and Alkaline Sodium Stearate at 70° C. in Exp. 6.
Horizontal — Normality of soap.
Vertical—"Color ratio" of filtrate.
Curve I—In presence of 0.005 N excess NaOH.
Curve II—In presence of 0.002 N excess NaOH.
Curve III — Neutral soap (from Figure 7).
Curve IV—In presence of .005 N excess stearic acid.

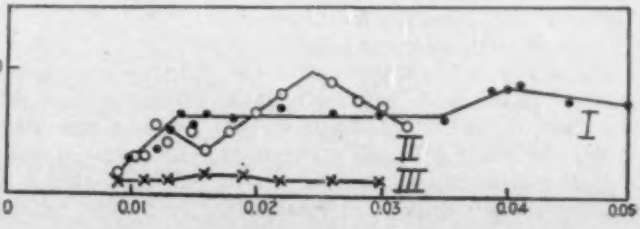


Fig. 9.
Oiled Carbon Black and Neutral Sodium Stearate at 70°, 60° and 50° in Exp. 7.
Horizontal—Normality of soap.
Vertical—"Color ratio of filtrate.
Curve I—at 70° C.
Curve II—at 60° C.
Curve III—at 50° C.

soaps; second, the relative effects of soaps in promoting the fading of certain dyed goods may be far from parallel with their powers to cleanse the goods.

Naked Carbon Black

The carbon black employed was the same as in previous work. Tubes of the soap solutions were prepared exactly as already described in the work on emulsions. Each was charged with 0.5 gram of the black and the contents were filtered on similar standardized papers after 40 minutes agitation. Each filtrate was collected until the top of the meniscus reached the 7 cc. mark on the graduate. Each was appropriately diluted with an alkaline solution of potassium oleate and compared in a colorimeter under artificial light with the cobalt-nickel-copper standard solution described in the first paper. The results were calculated to the "color ratio" for each filtrate made to a standard volume of 100 cc.

Experiment 5. Results on naked carbon black with neutral sodium stearate at 70°, 60° and 50° C. are given in Figure 7. The curve at 70° C. was further found to run on a level from 0.05 N to at least 0.10 N. Evidently the effect of temperature upon the power of neutral sodium stearate to deflocculate naked carbon black does not appear very closely parallel with its effect upon the power of the same soap to emulsify oil as indicated in Figures 1 and 2. As a deflocculant it seemed even more powerful at 50° C. than at 70° C., while as an emulsifier its power at 50° C. was a small fraction of its power at 70° C.

Experiment 6. Results on naked carbon black treated at 70° C. with alkaline or acid sodium stearate are given in Figure 8. The curve for neutral stearate is also transferred from Figure 7. The soap clearly appears a more powerful deflocculant of naked carbon black with increasing alkalinity. This is the direct reverse of the effects noted upon the emulsification of oil at 70° C. in Figures 1, 3, and 4.

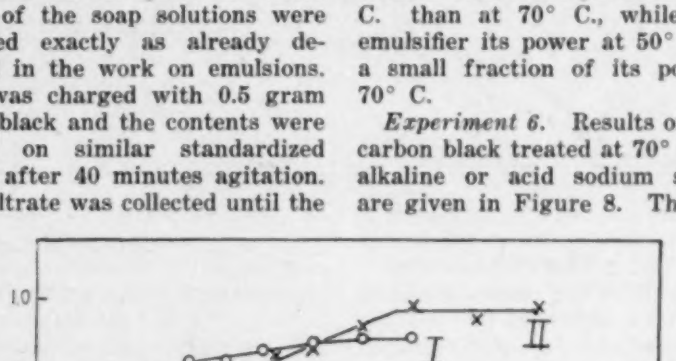


Fig. 10.
Oiled Carbon Black and Acid and Alkaline Sodium Stearate at 70° C. in Experiment 8.
Horizontal—Normality of soap.
Vertical—"Color ratio" of filtrate.
Curve I—In presence of 0.005 N. excess NaOH.
Curve II—In presence of 0.005 N. excess stearic acid.

Experiments with Oiled Carbon Black

Fifty grams of the same carbon black previously used was stirred with a spatula into a solution of 10 grams of the mineral oil in about 250 cc. petroleum ether contained in a stout beaker. The solvent was

cautiously evaporated off below the boiling point and the material was finally well dried at 105° C., with frequent stirring during the whole process. The oiled black was brushed through a 100-mesh sieve and thoroughly mixed. It was employed in exactly the same manner as the naked black, the weight used in each test being 0.6 gram, corresponding to 0.5 gram of the original black.

Experiment 7. Results on the oiled black at 70°, 60° and 50° C. are given in Figure 9. The much lower deflocculating power at 50° C. than at 70° C. is significant when compared with the similar behavior of emulsions (Figures 1 and 2) and the opposite behavior of naked black (Figure 7).

Experiment 8. Results on the oiled black in presence of excess sodium hydroxide or stearic acid are shown in Figure 10. In comparison with the similar curves for naked black (Figure 8), that for the acid soap is significantly higher, while that for alkaline soap is notably depressed, a behavior corresponding in order with the behavior of oil emulsions (Figures 3 and 4).

In conclusion, it therefore appears that the carbon black test, employing naked carbon black, can not afford very useful indications of the relative powers of various soaps to emulsify oil. The employment of oiled carbon black offers more promise. But a grave fault in technic must be first overcome. During filtration the larger particles of black tend to settle upon the filter and to themselves constitute a filtering medium of less porosity than the paper, so that a self-clearing filter will have to be devised. The work on oil emulsions is probably not so subject to this criticism because the larger globules of oil tend to rise and leave the filter clear.

Summary

Comparisons were made of the emulsifying or deflocculating powers of soap solutions as measured by the proportions of (1) mineral oil, (2) oil-soluble color, (3) naked carbon black, and (4) oiled carbon black, carried through filter papers under standard conditions. The results indicate no close parallel between the emulsification of oil, the distribution of oil-soluble color, or the deflocculation of naked carbon black. The use of oiled carbon black as a test object for determining emulsifying power offers some promise provided an appropriate technic can be devised.

L. C. WHITON IN EUROPE

Louis C. Whiton, representing Edouard Bataille in the United States left on January 8th for Europe. Mr. Whiton will make his headquarters at Paris and will spend the next two months inspecting several up to date Vegetable Oil Refining plants which use the Bataille Vacuum Neutralizing and Vacuum Bleaching Systems and also several new plants which are using non-inflammable solvents for the extraction of oil seeds. Another purpose of the trip is to inspect and become familiar with the recent improvements on the Bataille Super-Deodorizer which has added to its high vacuum equipment, means for obtaining high temperatures with the oil, when, as is frequently the case with American Oils, this is found advisable.

The Safety Factor in Drying Equipment

By L. R. CHRISTIE

Problems in Artificial Drying Which Are Met by the Equipment Manufacturer

THE natural tendency of materials to dry deceives many people in the belief that drying is a very simple problem. Consequently, it often happens in designing plants, that this process is given minor consideration although it may be the element which causes the success or failure of a manufacturing plant.

When nature's slow processes are depended upon, many materials go through a period of putrefaction during which the valuable characters are destroyed. On the other hand, if you try to hasten the drying process too much the desirable qualities are equally destroyed and again oxidation may destroy the valuable properties of some materials. There are several other conditions which may effect the product and it is therefore important that a careful study be made of the requirements before deciding as to the method of applying heat to accelerate drying. Heat is absolutely necessary, notwithstanding the frequently expressed opinion that drying can be done without heat if sufficient air is applied.

In the edible oil field the principal drying problem—more properly termed rejuvenating—is the recovery of the filtering medium, which is generally in the nature of an infusorial earth. This material is extremely light and dusty and the finer particles are the more valuable. If a strong current of air is passed through this material the fine particles are naturally carried away by the draft and almost impossible of recovery. For this reason, a rotary dryer has been developed which is substantially a rotary boiler in that it evaporates and removes moisture by direct evaporation without the use of any air to absorb or carry the moisture away, the process being continuous in operation. This same machine can also be used for burning out carbonaceous matter of decomposing compounds which may be accomplished by high temperatures. The fact that no air passes through the drying material, there is no medium for carrying away dust.

There are frequently by-products in this industry in the nature of spent grains, seeds, etc., some of which are very valuable if not excessively heated or oxidized. We have found that these materials, as a rule, will withstand fairly high temperatures while wet, provided these temperatures are transferred with sufficient rapidity to the wet material so as to modify the temperature as applied to the nearly dry material. For these conditions, a machine has been developed wherein the relatively high temperatures are first indirectly applied to the wet material by means of a flue having exceptionally large heating surface. After the heating medium has passed through this flue, it comes in direct contact with the nearly dried material flowing in a counter direction to it, so the result is that only dry gases come

(Continued on page 41)

Copra Sampling, Inspection and Analysis

By P. W. TOMPKINS

THE present extensive demand for copra, market changes due to large European consumption, the varying quality and grades obtainable or desired by crushers, regulations resulting in improved quality in some localities, the absence of such regulations in most places, and many other factors, makes the subject of inspection complicated, and requires someone in charge who is familiar with conditions, if anything like practical results are to be expected.

The character of cocoanut oil obtained, must necessarily reflect the quality or grade of copra from which it was derived and while some crushers have their own buyers on the spot to aid them in their selection, others reply on inspection at points of entry.

From time to time we are asked to outline methods which should be followed as a guide for unified procedure, but there is little more to be added to that which has already been touched upon in several previous articles appearing in these columns, beyond correlating the data as a whole and bringing the subject up to date.

Interpretation of results must be based on the knowledge of the particular copra grade or type being inspected. No independent interpretation can be made without this knowledge, since the characteristics of the copra from any one locality or district may normally be quite

Copra schooners loading at one of the Tahiti ports

different from that of another. For example, Cebu Sundried, Cook Island Sundried, Tahiti Sundried, and Fiji Sundried, etc., are distinctive types both in appearance and analysis, but the greatest difference lies in their appearance and the color and fatty acids of the oil. The smokedried copra and mixed copras from various places differ in like manner. Furthermore the record of maximum, minimum and average run of any type from any locality must cover a long period and knowledge of copra, if practical decisions are to result. As the phrase "fair average quality of the season" cannot be known until the season has passed, it renders this term quite meaningless without a full knowledge of conditions as they exist.

According to the character and origin of the copra, the fluorescence of the oil varies in intensity. Sundried copras which become dark in color as a result of age and exposure to elements of attack, yield oils with much more pronounced fluorescence than do the whiter, better preserved copras. Oil from smokedried copra shows marked fluorescence as a rule, but not more than that of the dark colored sundried copras. Smokedried copra has marked resistance to spoilage and insect attacks and particularly dampness, molding and fatty acid development resulting from dampness, the smoke acting as a preservative.

Causes of Variations

Copra types and characteristics are an inseparable reflection of the producing district and the environments surrounding harvesting and curing in the particular locality from where derived. When one stops to consider the tropical conditions prevailing where this commodity is grown commercially, and methods of handling and curing by the natives, it is natural to anticipate wide variations, which characterize the output of the numerous points of origin.

Differences occurring in copra inspection and analysis originates almost entirely in a lack of understanding the subject, and in the majority of cases, discrepancies are directly traceable to the manner of procuring and preparing the sample, and not to the examinations which follow. Unless the entire operation (sampling and preparation for analysis) can be handled in a representative manner, the results obtained are little short of useless. Without due precautions in sampling, no results, whether physical or chemical, can ever reflect what the sample is intended to show.

With such methods as prevail for harvesting copra by the natives and unforseen influences of transportation so frequently affecting the commodity, the idea of guaranteeing analytical results of primary material or that afloat is quite impractical. The use to which analytical results can reasonably be applied, is as a helpful means of determining or controlling grades not defined by appearances and to assist in factory control operations. Furthermore, until a uniform and comprehensive system of inspection is generally understood and followed, the results will fluctuate in proportion to the efficiency with which each step of the operation has been conducted. And as often as there are inaccurate samples, there will be inaccurate deductions, whether physical or chemical.

Methods of Sampling

Since the ratio of existing parts of any cargo can only be typified by eliminating elements of personal equation, selective hand sampling is obviously objectionable. There is no use of trying to represent, in a few pounds, something that by its very nature is visually as well as mathematically obscure in its proportions.

Foreign Commerce Association Rule No. 560, as well as the uniform copra contract, requires that samples be drawn "from at least every tenth sling load as discharged from the vessel," which is none too much where such large tonnage is involved. Let us see how this procedure works out in practice, taking for example a concrete case, where some 1050 long tons of copra were loaded into 30 cars and every eighth bucket sampled. As the

Two wings of copra boat with pneumatic system installed ready for discharge

Intake at mouth of pneumatic tube. Samples drawn near that point

average box car holds about 112 buckets, the entire shipment would represent about 3360 buckets. The scoop used for taking the sample is intended to hold sufficient material to permit a fair average being represented, and by this means about one and a half pounds is taken from each bucket. As every eighth sling was sampled, it in turn represented about 420 buckets, from each of which about one and a half pounds of copra was removed, or a total of about 630 pounds to represent the shipment as a whole.

When copra is discharged through the medium of the pneumatic system, the time required to load the average box car of approximately 35 tons requires about 60 minutes. It is then necessary to take a scoop full (1-½ pounds) about every five minutes, or in round figures approximately 12 times during the loading of the average car. If, as in the former example, 1050 long tons were being loaded into 30 cars, it would take about 30 working hours, and as the copra is sampled approximately every five minutes, one would have taken 360 samples, or about 540 pounds, to represent the shipment as a whole. The samples are drawn some three feet away from the suction intake at the required intervals, and as the copra is constantly shifting, mixing is continually going on at the point where the samples are drawn. Where sacked copra is involved 2 to 10 per cent of the lot should be sampled, and treated in every other respect as with the bulk material.

Preparing the Sample

Generally speaking, the bulk sample derived from each fifth or tenth sling, or every five minutes, as the case may be, is mixed, quar-

tered and reduced in size to about 100 to 200 pounds, depending on the tonnage (balance returned to cargo), which is sufficient to retain the average characteristics of the shipment when intended for analysis. The bulk sample, however, can only be reduced in this way to an amount that will not alter the proportionate ratio of existing parts of the shipment, in order to characterize the condition of the consignment as a whole. Only when the trade custom of grading copra by physical appearance is involved, can the bulk sample be further reduced without affecting any property of the sample that the eye is capable of discerning.

Of this reduced sample (100 to 200 pounds) about three-fourths is coarsely cut in a suitable power driven machine, mixing and quartering as usual. One of these quarters is again cut finer by a special copra shredder, mixed and quartered and a quarter of this put through a smaller disk of the shredding machine, which reduces it to the necessary size for laboratory use. It should be understood that appliances used for cutting or shredding copra for laboratory use must leave the oil intact and equally distributed, and is unlike crushing for large manufacturing purposes where the oil removed does not figure in any analytical results.

All these attempts at thoroughness are useless efforts if, after properly drawing the samples, only a few pieces are ground in some small hand mill. In such an event, the whole operation might just as well be omitted and any small grab sample taken, which will serve the purpose equally as well. Differences as a rule are not attributable to the

Pneumatic tubes from boat to box car. Compressed air pulls the copra from the vessel and discharges it under pressure into the box car

analysis, but to inefficient methods of procuring and preparing laboratory test samples. One has only to review some of the officially adopted methods of sampling coal, ores and other commodities, to realize that sampling and the preparation of samples for analysis has become an important scientific operation in industrial transactions.

It should be understood by those requiring copra sampling, that the amount necessarily taken to properly represent a cargo is considered a part of the delivery. Aside from that portion ground for analysis, a small type sample is always retained for three months, and if no requests are made for these reserves during the official period for which they are held, should be called for at the expiration of this time, as otherwise they are disposed of.

Methods of Analysis

Copra is usually examined for moisture, total oil yield, color of the pressed oil, free fatty acids (as oleic) and the proportion of loose dirt. When loose dirt is reported, it should state the size of screen used, without which the results will lack definite meaning or value. We always use Number 4 mesh screen for this purpose. The loose dirt being low in oil and high in free fatty acids (about 35 to 60 per cent of the oil), and usually carrying grits, which if in appreciable amounts clog and scratch the expellers, retarding the output and it is therefore advantageous to keep loose dirt as low as possible.

Oil is determined by extracting 10 grams with alcohol free ether or petroleum spirit distilling below 40°C for about 4 hours. The thimble is then removed, adhering solvent allowed to evaporate, and the copra ground in a mortar with fat free sand and re-extracted overnight, after washing the mortar and pestle. The solvent is distilled and the residue dried at 98 to 100° C, care being exercised to avoid over-heating, or too long heating which would result in lowering the free fatty acids by volatilization.

No attempt should be made to report the free fatty acids or color on the pressed oil unless the equipment is adequate to remove practically all the oil, leaving not *more* than 10 per cent in the cake. The free fatty acids and color determined in a partly expressed copra is usually higher than if completely expressed and much more so where the fatty acids are high. This is readily explained by the effect produced on exposed parts where the tissues are softened by elements of attack, and when in this state yield oil more freely, and are the portions highest in fatty acids and color. The harder and more resistent parts nearest the shell, having better protection are lower in fatty acids and color and require greater pressure to dislodge the oil.

It will therefore be seen, that if any methods are employed they should (in the absence of a proper press) be on the basis of the extracted oil only, since any properly equipped laboratory would have ample facilities for extraction. In this way reasonably uniform results (excluding color) can be obtained, as all the oil is recovered from the copra and on no other basis will concordant or trustworthy returns be procured. Furthermore, no analysis of copra should be reported on at all, unless adequate facilities are available for reducing

(*Continued on page 34*)

Determination of Detergency of Soap Products

A Progress Report of the Work to Date by the Subcommittee of the American Oil Chemists Society

THE formation of a subcommittee of the A. O. C. S. on Determination of Detergency was one of the results of the annual meeting of the society in May, 1925. The urgent need of standard methods to evaluate detergents was admitted by all of the members of the original Detergents Committee and was stressed by the Chairman, Mr. Campbell, in his 1925 report.

A meeting of the subcommittee was held at the Bureau of Standards, Washington, D. C., on September 28, 1925, at which ten members were present. The membership was subsequently increased and the personnel of this subcommittee is now shown on the page following.

At the Washington meeting it was the consensus of opinion that the detergent value of soaps and soap products was of so complex a nature and involved so many factors and variables that it could not be properly judged by criteria such as lathering power, surface tension or other physical measurements.

An actual washing test of some sort was considered to be the ultimate test of detergency, although it was admitted by all that the difficulties in developing a satisfactory washing test would be enormous.

After discussion of various washing test procedures the committee decided that the laboratory washing test and machine described by A. K. Church of Lever Bros. Co., offered the best possibilities from the standpoint of simplicity, cost and small size of samples involved.

From the beginning, the need of standard methods to evaluate detergency has been before the American Oil Chemists Society. This paper constitutes, in a sense, a history of the detergency movement. And although the results to date have been somewhat contradictory and inconclusive, the society may justifiably take pride in the work of its subcommittee. Mr. Hoyt's report will be supplemented by comments of collaborators in Oils and Fats for February.

The problem of preparing secondary standards for quantitatively recording color values of the soiled and washed clothes was undertaken by Dr. P. H. Walker of the Bureau of Standards. Dr. Walker in collaboration with his associate, Mr. Bruce, worked out a series of gray pastes, of uniform gradations of color sensation, made with mixtures of zinc oxide, carbon black, and white mineral oil. The care, time, and labor involved in preparing such secondary standards is very great, and for the use of the large personnel of the committee arrangements were made with the Munsell Color Co., of Baltimore, to furnish at small cost sets of standard gray papers approximating closely to the gradations of gray pastes that

had been prepared by Dr. Walker.

In addition to the pastes, Dr. Walker and Mr. Bruce subsequently worked out a graded series of twelve cloths soiled with definite increments of India ink, as a possibly desirable. The chroma of the "India ink" cloths was so different from that of the bluish-gray soiled and washed cloths that these particular "India ink" cloths were generally not satisfactory.

Members of the Committee

Edward Bauer, Kirk & Co., Chicago, Ill.

H. C. Bennett, Los Angeles Soap Co., Los Angeles, Calif.

J. S. Boulden, Wm. Waltke & Co., St. Louis, Mo.

Dr. J. C. Brier, Prof. Chem. Eng., University of Mich., Ann Arbor, Mich.

R. K. Brodie, Chem. Supt., Procter & Gamble Co., Ivorydale, O.

V. K. Cassady, Chief Chemist, Palmolive Co., Milwaukee, Wis.

A. K. Church, Chief Chemist, Lever Bros., Cambridge, Mass.

R. E. Divine, 284 Beach St., Hackensack, N. J.

Dr. J. S. Goldbaum, Chief Chemist, Fels & Co., Phila., Pa.

F. H. Guernsey, Chief Chemist, Cowles Detergent Co., Lockport, N. Y.

Dr. M. H. Ittner, Chief Chemist, Colgate & Co., New York, N. Y.

G. H. Johnson, Director of Research, Laundryowners National Assoc., Mellon Institute, Pittsburgh, Pa.

Frederick Kenney, City of New York Board of Purchase, Central Testing Laboratory, New York, N. Y.

C. P. Long, Globe Soap Co., St. Bernard, Ohio.

E. T. Marceau, Chem. Director, Gold Dust Corp., New York, N. Y.

Prof. E. B. Millard, Mass. Institute of Technology, Cambridge, Mass.

H. S. Mitchell, Swift & Co., Chicago, Ill.

J. R. Powell, Chief Chemist, Armour Soap Works, 1355 West 31st St., Chicago, Ill.

W. S. Rapelje, Kirkman's & Son, Brooklyn, N. Y.

W. T. Reese, Chief Chemist, Peet Bros., Kansas City, Kansas.

J. G. Vail, Chemical Director, Philadlephia Quartz Co., Phila., Pa.

F. W. Smither, Bureau of Standards, Washington, D. C.

Dr. P. H. Walker, Bureau of Standards, Washington, D. C.

L. F. Hoyt, Larkin Co., Inc., Buffalo, N. Y., Chairman.

sible secondary standard. Sets of 4 of these cloths of the shades most likely to be needed were prepared by the chairman according to directions furnished by Dr. Walker, and sent to each member of the committee. (In practice it is somewhat difficult to compare color of a woven fabric with the matte surface of a gray paper or paste and standard gray cloths are theoretically desirable. The chroma of the "India ink" cloths was so different from that of the bluish-gray soiled and washed cloths that these particular "India ink" cloths were generally not satisfactory.

The manufacture of the minature washing machine, of slightly modified design, was undertaken by R. K. Brodie, Chemical Supt. of the Proctor and Gamble Co. Thru the efforts of Mr. Brodie a very satisfactory machine was made available to members of the committee at the low cost of $15.00.

The program agreed upon at the Washington meeting was restricted

primarily to a study of the tentative washing test procedure itself to determine its reliability in the hands of a number of investigators, and called for comparative washing tests at 100°, 122°, and 160°F in distilled water of two soaps of widely different composition.

There was considerable and unavoidable delay in getting started on this year's program, the first of its kind. Late in February members of the committee received from the Chairman the collection of materials for this year's program, including the Munsell and "India ink" cloth color scales. The Detergency Set included a 60-yd. roll of 4-inch cotton sheeting; lampblack, edible tallow and lubricating oil for the soiling mixtures; and samples of a granular tallow soap and of powdered olive castile soap. Ten members of the committee received sets of standard gray pastes from Dr. Walker for trial. Washing machines were supplied to members by Mr. Brodie, on order.

Directions for soiling and washing, as supplied to members of the committee were as follows:—

A. Procedure for preparing soiled cloths.

The cotton sheeting contains considerable starch sizing, which must be removed before uniform soiling can be attained. This can be accomplished as follows: cut the sheeting into convenient lengths and boil for about 5 minutes in dilute HC1, (10 cc. 1.20 HC1 per liter), rinse, partially dry and iron out flat.

Experiments have indicated that it is not feasible to rigidly fix the amount of lampblack to be used in the soiling mixture since variation in technique of soiling will give different results with the same solution.

Soiling Mixture:—
5 grams Lubricating Oil
3 grams Edible Tallow
x grams Lampblack (x = 2 to 3)
2000 cc. Carbon Tetrachloride

Dissolve the oil, tallow, and lampblack in 1 liter of $CC1_4$ in a 2½ liter glass stoppered bottle (or a 2 quart jar provided with rubber ring and cover, if more convenient), shaking thoroly for 5 minutes. To the mixture add 1 liter of $CC1_4$ and filter rapidly thru several thicknesses of washed sheeting. Preserve the soiling solution in a closed container.

Pass a continuous strip of sheeting, of any convenient length, from which sizing has been removed as above described, through the soiling solution in a tray or dish and then thru a wringer. Dry the cloth rapidly with the aid of an electric fan or suspend for a few minutes in a drying chamber, and when dry press out flat with a warm iron.

This process should result in securing an even soil on the cloth and sufficient lampblack should be used (the amount can be determined only by trial) to produce a shade which will match the S48 of the Munsell gray scale.

Caution: Even with the standard soiling mixture containing no readily oxidizable constituents there is evidence that soiled cloths several days old do not wash out as white as freshly soiled cloths.

Therefore in this year's program, to avoid possible differences which might be caused by using soiled cloths of indefinite age, it has been considered advisable to specify that all washing tests should be run on soiled cloths not over one day old.

B. Procedure for washing test.

Connect up the washing machine to any convenient power source so that the wash wheel will have a speed of 250 r.p.m. with load. Provide a gas burner to maintain the desired degree of heat in the washing machine during the test.

Dissolve 5.00 grams of a standard soap sample, as received, in 500 cc. of distilled water, using heat, if necessary. Dilute to 1 liter with distilled water and adjust to the desired temperature. Fasten a strip of soiled cloth, shade S48, on the wash wheel, pour the soap solution rapidly into the machine, run for 5 minutes at 250 r.p.m. maintaining the temperature of the solution at one of the definite prescribed temperatures. Stop the machine and drain off the soap solution. Add 1 liter of rinse water (distilled water), run the wash wheel for 1 minute and drain. Repeat the rinsing twice more. Remove cloth and when nearly dry press with a warm iron, fold to four thicknesses and record its color value on the Munsell gray paper scale. Repeat the entire washing and rinsing process as above *on the same cloth* and record the color value after the third and fifth washing.

Note:—It should be distinctly understood that these washing test directions are to be considered *not* as final or standard, but rather as tentative directions subject to modification and improvement as the result of collaborative work.

Analyses of the Soaps used in this year's program as made by Messrs. Smither and Bower of the Bureau of Standards showed the composition given below.

Color	Powdered castile soap White	Granular tallow soap Light green
Volatile at 105° C.	2.5%	2.3%
Water Insoluble	0.1%	1.6%
Alcohol insoluable	1.2%	7.3% (5.8% Na_2CO_3, balance silicate of soda)
Sodium chloride	2.4%	0.8%
Anhydrous* soap, by difference	93.8%	88.0%
Free alkali	0.0%	0.0%
Free fatty acid	0.0%	0.0%
Titer of fatty acids	19.8° C.	40.2° C.

Reports of results were received from the committee and associates:

Mr. Boulden, Wm. Waltke & Co.

Mr. Brodie and Dr. Preston, Proctor and Gamble Co.

Mr. Cassady, Palmolive Co.

Mr. Church and Mr. Boucher, Lever Bros.

Mr. Guernsey, Cowles Detergent Co.

Dr. Millard and Dr. Ashdown, Mass., Institute of Technology.

Mr. Mitchell, Swift & Co.

Mr. Powell, Armour & Co.

Mr. Reese, Peet Bros.

Mr. Smither and Mr. Bower, Bureau of Standards.

Mr. Vail and Mr. Carter, Philadelphia Quartz Co.

Mr. Hoyt, Larkin Co., Inc.

The time available for carrying

* Note: This value would include the small amount of glycerine present, for which no separate analysis was made.

out the program was limited and probably prevented more complete returns.

Comments and results of collaborators are as shown in the tables below and on the following pages.

A. O. C. S. Detergency Test Results 1926

Tallow Soap

(Munsell Paper Scale Readings)

Conditions of Test	1	2	3	4	5	6	7	8	9	10	11	12
Temp. 100° F.												
After 1st Wash	64	60	55	60	64	60	64	52	64	55	64	64
" 3rd "	67	64	55	64	71	67	67	67	67	60 —	67	71
" 5th "	71	64	55 +	64	76	71	71	71	67	60 +	73	76
Temp. 122° F.												
After 1st Wash	67	64	55	60	64	60	64	60	64	60 —	64	64
" 3rd "	71	67	55	64	71	71	67	71	67	60	71	71
" 5th "	71	67	55 +	64	76	76	71	76	67	64 —	76	76
Temp. 160° F.												
After 1st Wash	64	64	55 +	60	64	64	64	55	64	60 —	64	64
" 3rd "	71	67	60	64	67	71	71	64	67	60 +	71	67–71
" 5th "	71	67	60 +	67	71	80	76	71	67	64	76	76–80

A. O. C. S. Detergency Test Results 1926

Olive Castile Soap

(Munsell Paper Scale Readings)

Conditions of Test	1	2	3	4	5	6	7	8	9	10	11	12
Temp. 100° F.												
After 1st Wash	64	60	52	67	64	60	60	60	60	55 +	60	64
" 3rd "	71	64	52	67	67	67	64	67	64	60 —	67	67–71
" 5th "	71	67	55	71	71	67	67	76	67	60	71	76
Temp. 122° F.												
After 1st Wash	64	64	48 +	60	64	60	60	60	64	60 —	64	64
" 3rd "	71	64	52 —	64	71	64	64	64	67	60	71	67
" 5th "	71	67	52	67	76	67	67	67	67	60	76	71
Temp. 160 ° F.												
After 1st Wash	67	64	55	60	64	64	64	60	64	60 —	64	64
" 3rd "	71	67	55 +	64	71	67	67	67	67	60	71	67–71
" 5th "	71	67	55	67	76	71	67	71	67	60	76	76

A. O. C. S. Detergency Test Results 1926

Tallow Soap

Gray Pastes Readings

Conditions of Test	1	2	3	4	5
Note: Color of cloth at start of all tests reported as matching					
Paste No.	8	9	10	10	10
Temp. 100° F.					
After 1st Wash	6	5	5–6	5	5
" 3rd "	5—	3	4	4	4
" 5th "	5	3	3	4	3
Temp. 122° F.					
After 1st Wash	5—	5	5	5	5
" 3rd "	5	3	4	4	4
" 5th "	5	3	3	4	3
Temp. 160° F.					
After 1st Wash	5	4	5	5	5
" 3rd "	4	3	4	4	4–3
" 5th "	4	3	3	4	3–2

A. O. C. S. Detergency Test Results 1926

Olive Castile Soap

Gray Pastes Readings

Conditions of Test	1	2	3	4	5
Note: Color of cloth at start of all tests reported as matching					
Paste No.	8	9	10	10	10
Temp. 100° F.					
After 1st Wash	7	5	5–6	5	5
" 3rd "	6	3	5	5	4
" 5th "	6	3	5	4	3
Temp. 122° F.					
After 1st Wash	7	5	5–6	5	5–4
" 3rd "	7	3	5	4	4
" 5th "	6	3	5	4	3
Temp. 760° F.					
After 1st Wash	6	4	5–6	5	5
" 3rd "	5	3	4	4	4
" 5th "	6	3	4	4	3

This paper will be concluded in the February number of OILS AND FATS.

Determination of Detergency of Soap Products

(Continued from page 28)

a large bulk sample, and if the facilities are not available the figures submitted, whether from the pressed or extracted oil will have very little value as a reliable or just basis of consideration. It must be perfectly obvious, that to correctly represent a thousand or so tons of any material like copra in a 10 gram sample, it must be remarkably uniform, and to obtain this, must be prepared with all the precautions and care set forth, or else the results will be misleading.

David Wesson left for New Orleans, January 8. He will be gone a month, lecturing at several Agricultural Colleges in the South on Cottonseed and its Products.

Standard Color Glasses

By H. J. MORRISON

Procter & Gamble Company

CERTAIN standard color glasses largely used for the reading of liquids consist of a clear glass base upon which a varying thickness of the desired color is superimposed on one or both sides.

Those who have not looked up the matter of manufacturing these glasses have various ideas as to how they are prepared. It might, therefore, be of interest to explain some of the details of their preparation.

Glasses of this character are known as "flashed." The method of making them is in the main as follows: Two pots of molten glass are prepared, one containing the clear or uncolored glass, the other containing a glass having the same thermal expansion as the clear glass colored to the proper hue and value.

The glass blower inserts his blow pipe into the pot of clear glass and builds up thereon, by successively cooling slightly and redipping, a ball of "metal" of a size which, in his judgment, will give the results sought. This ball is now blown to a greater or lesser extent, then dipped into the pot of the molten colored glass, and thus coated with a layer of this colored glass. This is now blown to a large size bubble of glass of a more or less spheroidal shape. When it has reached a proper size, it is then drawn so that the middle portion is of a cylindrical shape. After this has cooled sufficiently, the rounded ends are removed and the cylinder cut lengthwise. This main portion is then softened by heat and flattened. It will have upon one side a layer of colored glass which, however, will vary somewhat in thickness in various parts of the sheet as will also the total thickness.

If the blower had, after gathering his ball of "metal" from the pot of white glass, blown it to a considerably larger sphere than in the case described above, then dipped it into the pot of colored glass and had subsequently blown it to approximately the same final size as previously, it is at once apparent that he would have in this case a glass coated with a thicker layer of colored glass, i. e., the ratio of colored to clear glass is increased. By manipulating these variables, glasses of various thicknesses of the colored glass are produced.

In many cases, one will note that the color glasses in use are colored on both sides, i. e., there are two thin layers of colored glass between which there is clear glass. These are made by first dipping the blow pipe into the colored glass pot and gathering a certain amount of this, then into the clear glass pot, and finally coated on the outside with the colored glass. Upon blowing this then, it follows that a color glass will form both the outer and the inner surface.

Glass blowers become quite dexterous and can blow and control these shapes with considerable dexterity. It is, however, impossible to predetermine the color value or control exactly the thickness of the

clear glass or of the coating colored glass. It is, therefore, necessary after these glasses have been cut to the size used for the various instruments to sort and standardize them by matching.

The variations are best shown by giving the thickness in thousandths of the inch on a number of such glasses comprising several sets and sold and guaranteed to have equivalent color values. Those colored on both sides are marked B. S., and if on one side only by O. S.

Red glasses	Thickness in inches No. 1 set	No. 2 set	No. 3 set
0.1	.083 B.S.	.125 O.S.	.110 O.S.
0.2	.071 B.S.	.107 O.S.	.110 O.S.
0.3	.084 B.S.	.064 O.S.	.113 O.S.
0.4	.134 O.S.	.056 O.S.	.090 O.S
0.5		.061 O.S.	.063 O.S.
0.6	.095 B.S.	.055 O.S.	.117 O.S.
0.7	.084 B.S.	.087 O.S.	.080 O.S.
0.8	.086 B.S.	.103 O.S.	.085 O.S.
0.9	.067 B.S.	.074 O.S.	.070 O.S.
1.2	.081 B.S.	.103 O.S.	.073 O.S
2.3	.082 B.S.	.092 O.S.	.099 O.S.
3.1	.086 B.S.	.108 O.S.	.107 O.S.
4.1	.082 B.S.	.075 O.S.	
5.1	.098 B.S.	.125 O.S.	.070 O.S.
6.2	.089 B.S.	.082 O.S.	.079 O.S.
7.0	.097 B.S.	.092 O.S.	.074 O.S.
8.5	.098 B.S.	.102 O.S.	.094 O.S
9.0		.102 O.S.	.090 O.S.
10.0	.089 B.S.	.083 O.S.	
15.5		.125 O.S.	
20.0	.145 B.S.	.113 O.S.	.133 O.S.
40.0		.147 O.S.	.154 O.S.
50.0	.180 O.S.		

It will be noted that the variations in total thickness are as much as 300 per cent, that the variations are haphazard and not in any order comparable with the color value, that the thickness for the same color value varies widely in different sets.

It is not possible to measure the colored layers, but by examining the cross section and especially by viewing the end cross section the variations of the colored portion can be seen. Many glasses may be found in which the colored film varies widely in thickness from one side to the other.

The clear glass is made of as colorless a glass as practical, but nevertheless always contains some color. The thickness of the clear glass which backs up the actual colored glass will, therefore, alter the color value as this ratio varies. In the glasses which are ordinarily used, there may be a variation in the thickness of the colored layer from one end or side of the glass to the other. The varying thicknesses and changing ratios of the glasses affect all the various physical phenomena entering into color reading, such as dispersion, absorption, luminosity, etc.

The usual rules governing the reading of colors limit the number of glasses to be superimposed, in any one reading of a color. It is, of course, evident that a single glass is the best for a standard. The greater the number of glasses, the greater is the obstruction to the light. The same thickness in a single piece will not obstruct the passage of the light in anything like the degree which the same thickness made up of several separate glasses will.

Color type glasses are not a true or scientifically correct method of reading liquids. This is well understood by all who have given thought to the subject. The convenience and simplicity of such type, however, commend them for the daily use in routine work by both the scientific worker and the non-technical user. Also, it is only by comparison with some standard color that colors can be expressed as such. Any really scientific method would take into consideration all

of the various colors present, although one may predominate almost exclusively. Such scientific methods would express the value in terms quite unintelligible to the average user of the results.

The trades in many lines, which have color standards for their commodities, express their colors in given shades of a certain set of standards. This has become so ingrained and is so widely known in most instances that it would be almost impossible to uproot it and supplement another standard for it. Therefore, it seems that the best method of procedure is to still use color glasses, but improve them to as large an extent as possible, and especially to make them duplicate for any given color value. It would seem that this could be accomplished by the use of wedges of solid glass, whereby the color glass being made to a standard formula, the wedges being ground to a given gauge should be then readily standardized and be directly comparable one with another.

The use of wedges is not new or untried. Heretofore, however, in practically all of the wedge machines, the various colors necessary for reading the composite colors of different commodities have been on separate pieces. It is well known by those who have had practice in color reading by glass standards that where two or more color variables are allowed, it is very difficult to get checks even by the same operator, but where only one variable is allowed and any other colors either fixed at a given amount or proportionately required, the checking is much closer.

By the use of such wedges, standard colors now used by the trade could be duplicated, and no change would be necessary in their rules and customs. Many of the variables now entering in when separate glasses are used would be eliminated. It is not contended, however, that wedges would give true colors, but it is contended that they would give more nearly check results and approximate the color of samples very closely, and be expressed directly in color standards now in use.

Castor Oil as a Lubricant

(*Continued from page 14.*)

tension runs parallel with low friction coefficient of metal and oil. This question, however, is being investigated.

The measurement of static coefficient of friction is made by one of two methods. Deeley[6] suggested a device which measures the oiliness by determining the friction between disks rotating at a slow speed and heavy load. Other investigators measure the static friction under high pressures. Loads applied to a lubricated inclined plane are permitted to slide just sufficiently to be detected electrically. The plane is manipulated until the angle of slip is determined and from which the coefficient of friction may be calculated.

Castor oil, it should be noted, gives both low coefficients of friction and low interfacial tensions. Its use in bearings and machines where it is not exposed to the air deserves careful consideration, and its employment in exposed bearings either dissolved in mineral oil or together with chemical stabilizing agents requires not only close attention but is worthy of serious and painstaking original investigation.

Domestic Exports of Vegetable Oils, Expressed, from the United States During November

COTTONSEED OIL

Countries	Crude Pounds	Refined Pounds	Corn oil Pounds	Cocoa butter Pounds	Coconut oil Pounds	Linseed oil Pounds	Soybean oil Pounds
Belgium	.....	42,517	....	.....	.....	.....	.....
Den. and Far. Is.	.....	19,320	....	.....	.....	.....	.....
France	.....	90,386	....	.....	.....	.....	.....
Germany	.....	35,928	....	.....	.....	.....	.....
Irish Fr. St.	.....	9,713	....	.....	.....	.....	.....
Netherlands	.....	23,561	....	.....	.....	.....	.....
Norway	.....	268,717	....	.....	.....	.....	.....
Sweden	.....	19,405	....	.....	.....	.....	.....
United Kingdom	.....	230	....	.....	.....	.....	.....
Canada	3,412,688	94,611	8,251	30,320	927,324	6,325	.....
Br. Honduras	.....	.....	....	.....	12,281	.....	.....
Costa Rica	.....	471	2,464	.....	.....	880	10,083
Guatemala	.....	1,218	....	.....	6,151	3,130	9,062
Honduras	.....	2,503	....	.....	411	1,996	.....
Nicaragua	810	1,257	....	.....	16,000	642	7,600
Panama	.....	84,940	....	96	991	1,943	.....
Salvador	.....	371	....	106	26,240	2,080	.....
Mexico	130,572	407,889	233	194	570,381	10,826	15,000
Newfld. and Lab.	1,800	.....	....	.....	385	.....	.....
Bermuda	.....	2,060	....	.....	.....	.....	.....
Jamaica	.....	12,559	....	.....	.....	.....	.....
Other Br. W. I.	.....	2,292	....	.....	.....	556	.....
Cuba	.....	176,147	....	508	65,319	37,608	44,150
Dom. Repub.	.....	1,875	....	.....	3,879	1,000	86,906
Dutch W. Ind.	.....	15,399	....	.....	.....	1,888	.....
Fr. W. Ind.	.....	.....	....	.....	.....	160	.....
Haitian Repub.	.....	15,885	....	.....	.....	4,835	3,200
Vir. Is. of U. S.	.....	825	35	.....	46	495	.....
Argentina	.....	62,289	....	.....	.....	2,000	.....
Bolivia	.....	.....	....	48	.....	750	.....
Brazil	.....	.....	....	.....	.....	1,985	.....
Chile	.....	142,949	....	288	4,689	.....	.....
Colombia	.....	3,870	....	284	7,339	27,583	16,810
Ecuador	.....	.....	....	.....	.....	369	900
Dutch Guiana	.....	13,112	....	.....	.....	750	.....
Peru	.....	1,288	....	284	11,486	535	.....
Venezuela	.....	982	....	.....	.....	5,701	.....
Br. India	.....	.....	....	.....	.....	.....	900
Ceylon	.....	210	....	.....	.....	.....	.....
China	.....	11,390	240	400	474	.....	1,800
Other D. E. I.	.....	15	....	.....	.....	.....	.....
Hongkong	.....	1,784	....	.....	.....	.....	.....
Japan, Inc. Chos.	.....	79,009	....	.....	.....	.....	.....
Philippine Is.	.....	6,476	....	.....	.....	1,875	.....
Australia	.....	1,528	....	.....	.....	.....	.....
Fr. Oceania	.....	36	....	.....	.....	2,739	.....
New Zealand	.....	4,115	....	.....	9,102	100	.....
Br. S. Afr.	.....	740	....	.....	.....	.....	49,860
Port. E. Afr.	.....	.....	....	.....	.....	.....	2,160
Total Quan.	3,545,870	1,659,872	11,523	32,528	1,662,498	118,751	248,431
Total Values	$273,101	$184,594	$1,708	$11,917	$149,339	$16,239	$32,343

Shipments from the United States to Non-Contiguous Territories

	Oils Expressed			
	Cottonseed		Linseed	
	Pounds	Dollars	Pounds	Dollars
Alaska	540	67	1,230	128
Hawaii	18,517	3,134	27,684	3,533
Porto Rico	11,415	1,360	93,979	11,548

Imports of Olives, Cocoanut Meat and Cocoanut Oil, Peanuts and Peanut Oil, and Edible Olive Oil into the United States During October

Countries	Olives in brine		Cocoanut, meat, dessicated, shredded, cut, or similarly prepared	
	Gallons	Dollars	Pounds	Dollars
France	85	179	.....	.....
Germany	.....	.....	21,546	5,353
Greece	3,956	2,361	.....	.....
Italy	45,871	12,910	.....	.....
Portugal	413	227	.....	.....
Spain	43,684	40,536	.....	.....
Canada	.....	.....	.....	.....
Honduras	.....	.....	.....	.....
Nicaragua	.....	.....	.....	.....
Panama	.....	.....	.....	.....
Jamaica	.....	.....	.....	.....
Cuba	.....	.....	.....	.....
Dominican Republic	.....	.....	.....	.....
British Malaya	.....	.....	.....	.....
Ceylon	.....	.....	2,785,607	227,663
Hongkong	28	18	60	11
Philippine Islands	.....	.....	2,504,082	210,186
British Oceania	.....	.....	.....	.....
French Oceania	.....	.....	.....	.....
Total	94,037	56,231	5,311,295	443,213

Countries	Copra		Cocoanut oil	
	Pounds	Dollars	Pounds	Dollars
France	111,807	5,273	.....	.....
Germany	.....	.....	.....	.....
Greece	.....	.....	.....	.....
Italy	.....	.....	.....	.....
Portugal	.....	.....	.....	.....
Spain	.....	.....	.....	.....
Canada	35,855	1,972	.....	.....
Honduras	221,449	9,078	.....	.....
Nicaragua	6,242	304	.....	.....
Panama	3,100	165	.....	.....
Jamaica	45,902	1,427	.....	.....
Cuba	7,265	324	.....	.....
Dominican Republic	.....	.....	550	41
British Malaya	7,827,089	399,115	.....	.....
Ceylon	.....	.....	.....	.....
Hongkong	.....	.....	.....	.....
Philippine Islands	25,138,281	1,245,043	21,218,904	1,852,494
British Oceania	4,075,238	214,929	.....	.....
French Oceania	2,153,343	99,558	.....	.....
Total	39,625,571	1,977,188	21,219,454	1,852,535

Abstracts

The following papers appear in *Industrial & Engineering Chemistry*, Vol. 18, No. 12—December, 1926:

Relationship during drying between the Acid Value of Linseed Oil and the Concentration of Cobalt Acetate—W. L. Evans, P. E. Marling and S. E. Lower.

Rate of Molecular Weights Increase in Boiling Linseed and China Wood Oils—J. S. Long and G. Wentz.

Fatty Oils as substitutes for Ethyl Alcohol in Citrus Flavors—H. A. Shuette and B. P. Domogalla.

The Rate of Polymerization of Perilla Oil—Maximillian Toch and T. T. Ling.

Sensitive Reaction for Carbon Disulphide—P. Saccardi. (Giorn. Chim. Ind. Appl., 1926, 8, 315-316.)

Anti-Rachitic Value of Irradiated Cholesterol—II. Separation into an Active and inactive Fraction—A. F. Hess, M. Weinstock and E. Sherman. (J. Biol. Chem., 1926, 70, 123-127.)

Saturated Aliphatic Alcohols from Sperm Oil and Spermaceti—E. André and T. Francois. (Compt. rend., 1926, 183, 663-665.)

Glycerides of Hydrogenated Whale Oil—G. Greitmann (Chem. Umschau, 32, 226, 1925).

The Raw Whale Oil had the following properties:

Iodine Number	145
Saponification Value	192
Free Acid	0.62%
Myristic Acid	About 5%
Palmitic Acid	" 5%
Stearic Acid	" 5%

After hydrogenation:

Iodine Number	1.3
Melting Point	55.5 degrees

By fractional solution (Boemer) and fractional precipitation (Heinz) the following glycerides were precipitated:

1st. Myristopalmitoarachine.....Melting point.. 49.5
2nd. Impure glycerides with enough acid radical C_{52}.....
Melting point..... 53.9
3rd. Palmitostearoarachine .....Melting point.. 57.3
4th. Distearoarachine .....Melting point.. 62.3
5th. Stearoarachobehenine or palmito.....Melting point.. 65.0
6th. Very small quantities of diarachobehenine or arachohibehenine.

The acid having the highest melting point was the Behenic Acid (79.0°). All the bodies here isolated were those formed by hydrogenation. The original oil contained small quantities of an unsaturated acid C_{14}. A little C_{16}, C_{18}, a great quantity of C_{20} and a little C_{22}. Apparently, all were present as mixed glycerides each containing an unsaturated radical of the Series C_{20} or C_{22}.

PEANUTS

Countries	Shelled		Not Shelled		Peanut Oil	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Germany	110,620	9,090	.....	....	.....	.....
Netherlands	.....	....	.....	....	15,404	1,887
Spain	.....	....	10,090	1,062	.....	.....
China	115,480	8,023	82,620	3,361	52,738	4,349
Hongkong	.....	....	1,760	207	93,256	10,706
Japan, Inc. Chosen	.....	....	20,900	1,260	.....	.....
Total	226,100	17,113	115,370	5,890	161,398	16,942

OLIVE OIL, EDIBLE

Countries	In packages weighing less than 40 pounds		Other	
	Pounds	Dollars	Pounds	Dollars
France	121,338	16,629	172,913	29,506
Germany	.....	.....	30,132	912
Italy	3,117,747	542,183	711,972	161,748
Malta, Gozo and Cyprus Is.	25,635	4,597	.....	.....
Netherlands	.....	.....	2,283	460
Portugal	12,115	2,490	.....	.....
Spain	76,510	14,211	512,678	88,502
Total	3,353,345	580,118	1,429,978	281,128

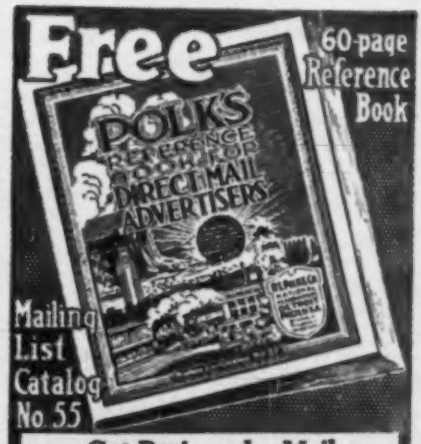
The Safety Factor in Drying Equipment

(*Continued from page 22*)

in contact with the dry material.

While we have referred to high temperatures with these machines, this is used only in a relative sense and the machine is more properly described as a low temperature machine depending largely on the natural affinity of air for moisture; but on account of its design, the initial temperatures are considerably higher than might ordinarily be used resulting in greater efficiency and economy in size of apparatus.

As stated, all drying problems should have very careful study as to their characteristics which determine the best method of drying and it is particularly important to consider the cost of operation more than the first cost of the apparatus.



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